

Addressing the Nuclear Waste Issue

Overview

The environmental concern over nuclear waste management presents a formidable barrier to increased use of nuclear energy in the United States at a time when global climate change concerns and the need for energy independence have increased interest in nuclear energy. At present, waste that results from generating nuclear power will take more than 100,000 years to decay to the natural radioactive levels of uranium ore. The nation is pursuing a geologic repository at Yucca Mountain that, if approved, will have a high probability of isolating high-level wastes for this extended period. However, given reasonable assumptions of future nuclear power production, more repositories likely will be needed and, given the difficulty the country has experienced in licensing Yucca Mountain, alternative paths should be vigorously pursued for the future for handling spent fuel from reactors.

With the single exception of waste management, every step in the nuclear fuel cycle has been successfully demonstrated by the international nuclear industry. Now envision a technology that can separate and transform most of the long-lasting radioactive elements from the waste so that the necessary isolation time of waste is reduced to less than 1,000 years, well within the lifetime of human-made containers. Visualize a technology that significantly reduces the radiotoxicity of nuclear waste and, at the same time, extracts a substantial amount of energy for the power grid. It is the vision of a clean nuclear fuel cycle—largely free of long-term hazards—that has inspired a dozen nations around the globe to evaluate this promising option.

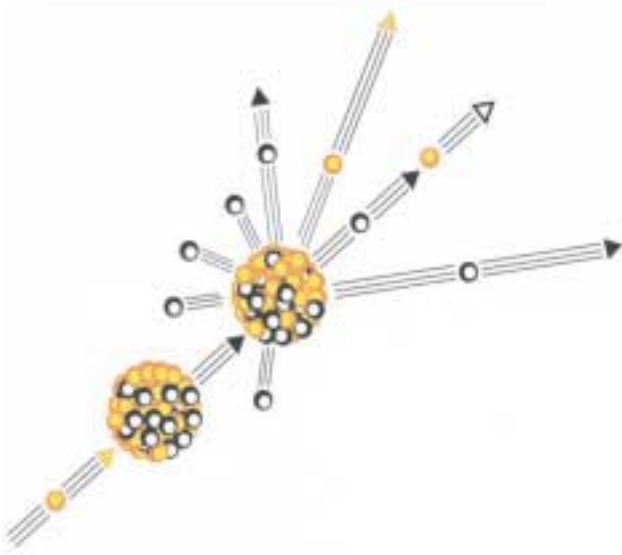


The United States has joined international efforts to evaluate the potential of advanced nuclear fuel cycles and the partitioning and transmutation of nuclear waste.

How Does Transmutation Work?

Our concept of transmutation is based upon 20th century nuclear physics, not the chemical process imagined by the infamous 18th century alchemists. By transmutation, we mean the nuclear transformation of heavy elements by using fission with high-energy neutrons. Such a technique transforms a radiotoxic, long-lived element such as plutonium into products that pose far less disposal challenges as they are mostly stable or short-lived.

Plutonium and the minor actinides are mainly responsible for the long-term radiotoxicity of nuclear wastes. If these elements are removed from spent nuclear fuel and undergo fission, the remaining waste loses most of its long-term radiotoxicity. Moreover, transmuting plutonium eliminates the concerns about future diversion for nuclear weapons.



The Problem

The current set of nuclear reactors operating in the United States today are expected to produce more than 90,000 tons of nuclear waste, thereby exceeding the current statutory limit at the Yucca Mountain Federal Repository. As a result, modest growth of the current domestic nuclear electrical capacity would require construction and licensing of one new repository every 30 years. A technology that could further mitigate the environmental, safety, proliferation, and cost issues associated with nuclear waste disposal could lead to a future in which no additional repositories are required.

A Solution

The Department of Energy has launched the Advanced Accelerator Applications (AAA) program—a partnership involving DOE laboratories, the private sector, and several universities—to provide alternative solutions to the issue of waste management. The program's goal is to develop technologies that reduce the long-lived hazardous elements in spent nuclear fuel, thereby dramatically lessening the radiotoxicity, mass, time, and proliferation risks relative to storing untreated spent nuclear fuel in geologic repositories. The AAA program's mission is to demonstrate the practicality and value of innovative technologies that can separate and transmute long-lived actinides and fission products.

What are these long-lasting elements? They are plutonium, so-called minor-actinides (such as neptunium, americium, and curium), and a few long-lived fission products, all of which constitute only about 1% of the spent fuel. These hazardous elements can be separated and transmuted in power-producing reactors and accelerator-driven systems, thereby reducing the necessary isolation time of nuclear waste to less than 1,000 years.

Transmutation cannot replace the current need for a national repository, but a successful transmutation program will significantly reduce the requirements and burden of disposal of nuclear wastes. As a result, transmutation could remove the waste management issue as a barrier to expanded use of nuclear power to address environmental and economic issues faced by the United States and the world.

Issues and Challenges

Transmutation is a high-technology solution to the nuclear waste issue. Critics and proponents alike have identified four areas of potential concern:

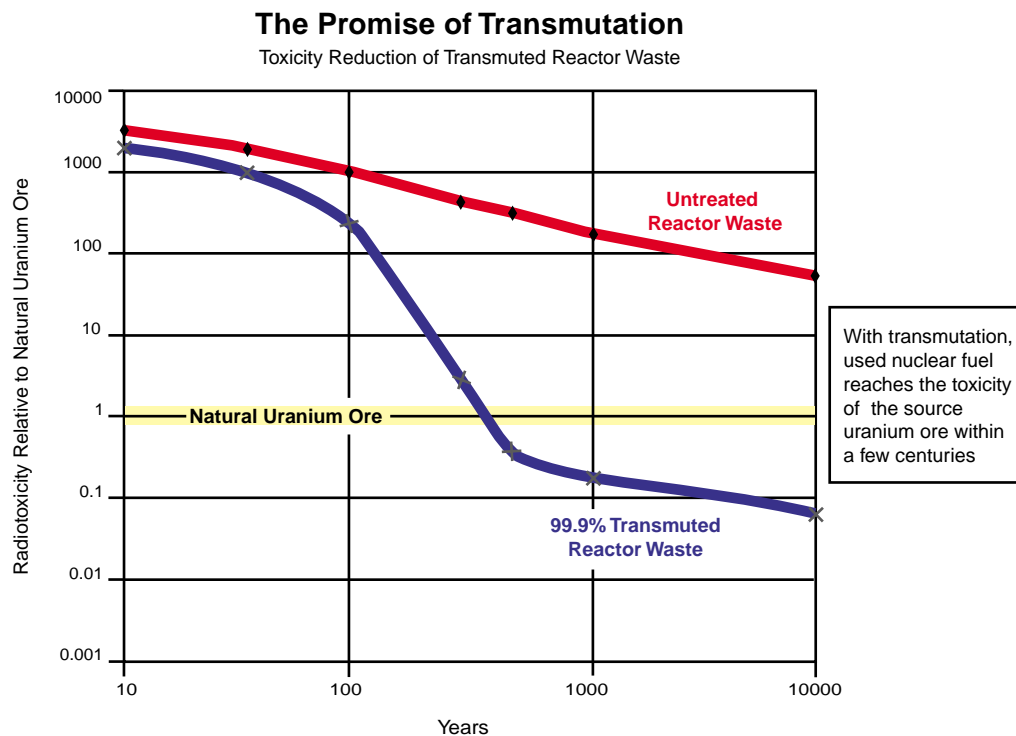
- The costs and time to develop waste transmutation technologies.
- The technical feasibility of the necessary fuels and materials performance, transmutation systems integration, and separations chemistry.
- Possible near-term safety issues and environmental impacts.
- Proliferation risks from reprocessing spent commercial nuclear fuel.

The AAA program is focused on addressing these challenges with cost-effective solutions. The partitioning and transmutation approach involves trading off near-term costs and risks for greatly reduced requirements for long-term isolation. Rather than shifting the responsibility to future generations, transmutation provides a current-generation solution to nuclear waste disposal and avoids the buildup of future wastes.

Goals and Objectives

AAA's mission is to demonstrate the practicality and value of transmuting long-lived actinides and fission products. The AAA program has established the following demanding goals to meet this mission:

- **Improve long-term public safety** by reducing the radiotoxicity of nuclear waste below that of natural uranium ore within a period of 1,000 years, as well as reducing the dose to future inhabitants by 99%.
- **Provide benefits to the national repository** by reducing the mass of commercial spent fuel by 95% and heat loads in the repository by 90%.
- **Reduce the proliferation risk from plutonium in commercial spent fuel** by reducing the inventory of plutonium by 99%.
- **Improve prospects for nuclear power** by providing a viable and economically feasible waste management option for commercial spent fuel.



Major AAA Participants

DOE Laboratories:

Los Alamos National Laboratory
Argonne National Laboratory
Savannah River Site

Industry participants:

Burns and Roe Engineering, Inc.
General Atomics

University participants:

University of Michigan
University of Nevada
University of California at Berkeley
University of Texas

For more information, contact

Gregory J. Van Tuyle
Mail Stop H816
Los Alamos National Laboratory
Los Alamos, NM 87545
505-665-4581
vantuyle@lanl.gov

R. Bruce Matthews
Mail Stop H816
Los Alamos National Laboratory
Los Alamos, NM 87545
505-665-5478
rbmatthews@lanl.gov

Los Alamos National Laboratory, an affirmative action/equal opportunity employer, is operated by the University of California for the US Department of Energy.

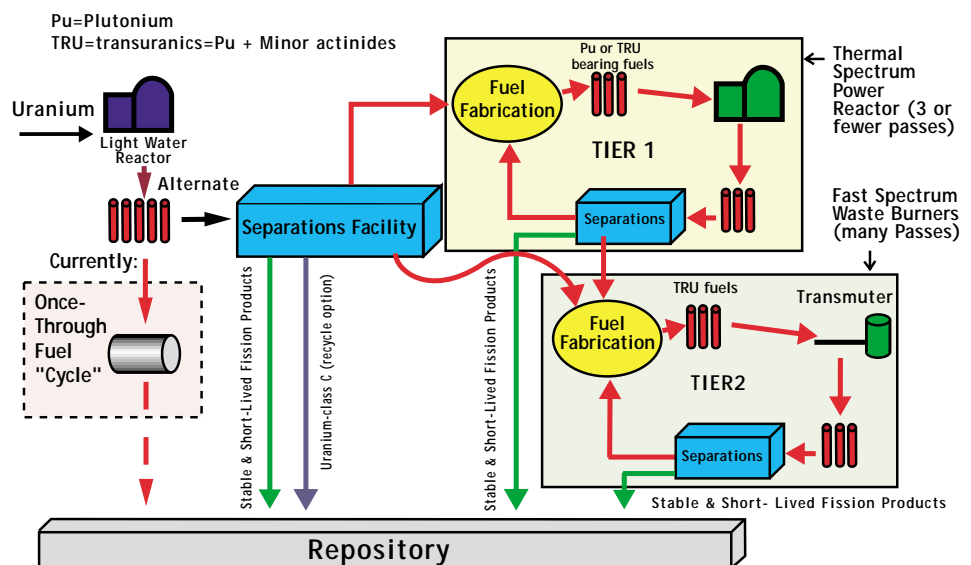
LALP-01-227
October 2001



Taking the Next Step

At present, utilities are requesting extended licenses for existing light-water reactors and for interim storage of spent nuclear fuel. The intended next step is to open Yucca Mountain and store (retrievably) spent nuclear fuel. With economic, environmental, and energy independence drivers to persuade utilities to order new light-water reactors, and a national policy that addresses reprocessing of spent nuclear fuel, utilities would be able to recycle mixed-oxide fuel in advanced light-water reactors and perhaps high-temperature gas-cooled reactors. This would serve to burn down excess plutonium and extract a significant amount of the energy still present in spent commercial fuel. It also serves as an important first step in a two-tier process, as illustrated in the figure below.

Multi-Tier Fuel-Cycle Approach to Nuclear Waste Management



The nation then can dispose of the minor actinides produced in the power reactors using transmutation systems, shown in the figure as Tier 2. To have this capability available for the third decade of the 21st century, we need to demonstrate the technical, economic, environmental, and nonproliferation benefits of transmutation. There are significant engineering challenges in accomplishing this part of the mission, but as part of an international cooperative effort the work can be completed before the next generation of plants has generated new minor-actinide waste streams for processing.

In the long term, the US could extend the nuclear fuel cycle with advanced liquid metal cooled reactors (ALMRs), which can extract the full energy content of natural uranium. The ALMR system would provide a sustainable energy supply well into the next millennium. In addition to Yucca Mountain, transmutation systems operational by 2040 would provide the essential bridge to a clean nuclear fuel cycle free of the long-term hazards currently posing disposal challenges.